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Role of renewable energy technologies in generating sustainable livelihoods

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Abstract

This paper discusses the current energy status, choice of energy options and potential of renewable energy systems for creating sustainable livelihoods in rural areas. It includes six case studies of successful projects spread all over India and covering different technologies and scales of operation. It also includes a proposed outline for training of Renewable Energy Technicians and their job opportunities.

Keywords: Livelihoods; Renewables; Rural; Sustainability

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1. Preamble

Rural urban divide is one of the most corroding and insidious residues of Industrial Revolution. According to Habitat Studies, the world is urbanizing at a rapid rate e.g. urban population was 30% in 1959, 47% in 2000 and is expected to go to 60% by 2030. An urban population of 1.9 billion now will jump to 3.9 billion by 2030 in less developed regions according to UN Report [1].

This migration is not only a talent drain on rural systems but also unsustainable ecologically and economically because people need food and not pollutants to live upon. But why do people migrate to urban areas—one central reason is search for livelihood. If these livelihoods could be generated in rural areas without changing their inbuilt sustainability, it could make rural areas attractive to live in and thereby regenerate themselves into rurban communities i.e. rural landscape with urban services such as clean water, quality energy, waste management and sanitary installations. This is possible now through decentralized systems based on renewable energy and associated technologies. On the other hand, green cities with urban agriculture could also converge to a rurban paradigm. It is, therefore, appropriate to examine RET based enterprises required to transform these possibilities into engines of livelihood generation and development without sacrificing sustainability. In fact, a key index of development should be the capital cost of unit sustainable livelihood generation. Sustainable livelihood means not only income generating activities, but creation of long lasting, ecologically stable and economically productive enterprises according to Gupta [2].

2. Nature of rural enterprises

Distinctive characteristic of a rural area is the cultivation of food grains, vegetables, cash crops, fruits and plantation crops etc., depending upon the agro geo climatic conditions. First, priority enterprises will therefore be based on food processing involving modern process of handling, processing and storage. Coupled to these can be enterprises based on upgrading of habitation, healthcare, learning facilities, water supply and sanitation. Resource augmentation such as rainfall harvesting, vermicomposting of solid wastes, biogas based liquid organic waste handling, producer gas based power systems using non-edible oils and agro wastes and crop residues via a gasifier can give power, thermal energy for processing and handle the

wastes thereby mitigating problems of pollution. Electric four wheelers and cycles using sun powered charging of batteries will provide local and internal transportation and internet shops will provide information and communication to/from other villages/markets. These are all capital intensive and suitable quantum of investment at viable interest rates will have to be garnered on a bankable/reliable long-term micro credit basis for economic capacity building. Skills have to be upgraded to handle these operations in an effective manner.

3. Role of energy

Energy is the driving force of processes, which converts matter to products or energize the global cycles determining environmental phenomena. However, all resources of energy are distributed unevenly in space and most of the renewables have a temporal variation as well. Table 1 presents the world scale status of primary energy resources from Goldemberg [3]. Fig. 1 shows the geographical distribution of per capita energy consumption based on the 1998 World Resource Institute Report [4], clearly indicating the inequity between regions. These have to be narrowed by using end use efficiency and demand side management in large demand centers and by using renewables increasingly in low load centeres so as not to effect climatic cycles and add to pollution overloads. However, both avenues have to be used throughout the world for offsetting development and population generated increments in demand.

4. Why renewable energy

Global parameters driving the movement for renewables and energy efficiency as a tool of demand side management and higher efficiency of generation using conven-

Table 1
World primary energy consumption in 1998 [3]

Source	Primary energy (EJ-1018 J)		Primary energy (109 TOE)		Percentage of total (%)	
Fossil fuels		320		7.63		79.6
Oil	142		3.39		35.3	
Natural gas	85		2.02		21.1	
Coal	93		2.22		23.1	
Renewables		56		1.33		13.9
Large hydro	9		0.21		2.2	
Traditional biomass	38		0.91		9.5	
‘New’ renewables	9		0.21		2.2	
Nuclear		26		0.62		6.5
Total		402		9.58		100.0

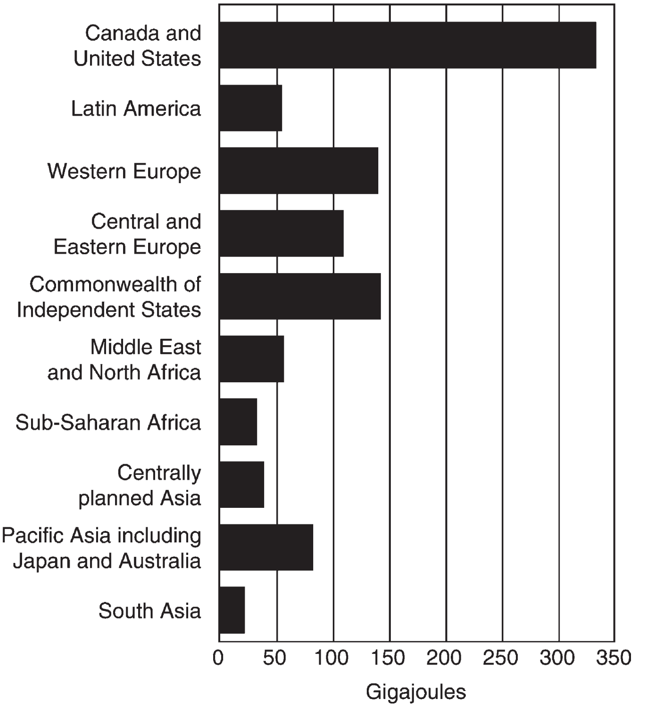

Fig. 1. Primary per capita energy consumption (commercial and non-commercial) by region, 1995 [4].

tional fuels are because of clean development mechanisms required to obviate climatic change effects, to reduce pollution and ozone hole exigencies without sacrificing energy security. Developing countries have additional considerations of energy quality for urban population, energy security for industries and agriculture and of energy availability for rural subsistence as well as development. The twin needs of rural areas are meeting the basic needs such as water supply, household and street lighting, cleaner cooking and generating livelihoods through clean, sustainable rural industrialization. In view of the distributed nature of sunshine, availability of flowing/falling water and wind as appropriate, availability of organic dairy and livestock wastes, crop residues and agro wastes, forest litter and prunings, possibility of growing trees bearing bio-oil kernels on the bunds, agri crops etc., renewable technologies using these inputs as substrates, for generating energy near points of use, become logistically appropriate.

However, making these options as marketable enterprises reliable enough to attract investments and skills require policy mechanisms, which are still sentiments or at the most operating instruments in their infancy handicapped by hesitation and uncertainty. Also, there are conflicting practices of providing free grid based power and piped water supply using ground water resources and diesel based pumps/gensets, which militate against any self-sufficient distributed systems requiring payments. Generation of affordability by training for skills leading to decentralized

entrepreneurs is the only lasting solution. All short-term populism will have to be stopped because non-remunerative financial resources will no longer be available with governments. In addition, the psychological spin offs are disastrous as they reduce poor but self-respecting people to beggars full of hopelessness and rob them of their initiatives.

5. Status of energy choices

Even though renewable sources are free and perennial, their conversion into useful energy via converters has its costs—ecological as well as economical. Table 2 [5] presents the budgetary estimates of costs of renewables and current status on a world wide basis. It can be easily seen that renewables are competitive in niche areas even now. These can be the starting point for creating rural enterprises. Fig. 2 shows the fall in capital costs curves for three of the most promising converter technologies: solar PV, windmills and micro turbines; as user experience and production volume grow, as per estimates of Nakicenovic et al. [6]. Micro turbine fuel costs are not included.

What follows, are a few success stories which were started from ground up by local initiatives/needs backed by enterprising skills employing technologies based on Renewable Energy Resources.

6. Case studies of successful enterprises

These have been selected so as to cover the entire country and spectrum of activities related to rural industrialization, provision of power, handling of wastes, providing food security and employing diverse renewable energy resources such as producer gas, solar PV, biogas, improved cook stoves, passive heating and rainfall harvesting.

In selecting these case studies, we have purposely not included well publicized case studies of Barefoot College SPV systems in Himalayas, Taragram Integrated enterprise in Madhya Pradesh and newly emerging cluster centered vermicomposting enterprises all over the country as they are already documented in literature.

6.1. Gasifier based silk reeling ovens in Karnataka and Andhra Pradesh [7]

6.1.1. Introduction

India and China produce bulk of natural silk in the world. Silk reeling is done as cottage industry in basin type of ovens in nearly 25,000 units, which use fire wood as fuel. Thirty thousand of units of another type use agro wastes as fuel and are still poor reelers. Average capacity is 100 kg of cocoon/day per reeling unit.

Table 2
Current status and potential future costs of renewable energy technologies [5]

Technology	Increase in installed capacity in past five years (% a year)	Operating capacity, end 1998	Capacity factor (%)	Energy production, 1998	Turnkey investment costs (US dollars kW)	Current energy cost per	Potential future energy cost
Biomass energy							
Electricity	≈3	40 GWe	25–80	160 TWh (e)	900–3000	5–15 ¢/kWh	4–10 ¢/kWh
Heata	≈3	>200 GWth	25–80	>700 TWh (th)	250–750	1–5 ¢/kWh	1–5 ¢/kWh
Ethanol	≈3	18 billion liters		420 PJ		8–25 $/GJ	6–10 $/GJ
Wind electricity	≈30	10 GWe	20–30	18 TWh (e)	1100–1700	5–13 ¢/kWh	3–10 ¢/kWh
Solar photovoltaic electricity	≈30	500 MWe	8–20	0.5 TWh (e)	5000–10000	25–125 ¢/kWh	5 or 6–25 ¢/kWh
Solar thermal electricity	≈5	400 MWe	20–35	1 TWh (e)	3000–4000	12–18 ¢/kWh	4–10 ¢/kWh
Low-temperature	≈8	18 GWth	8–20	14 TWh (th)	500–1700	3–20 ¢/kWh	2 or 3–10 ¢/kWh
Solar heat		(30 million m2)					
Hydroelectricity							
Large	≈2	640 GWe	35–60	2510 TWh (e)	1000–3500	2–8 ¢/kWh	2–8 ¢/kWh
Small	≈3	23 GWe	20–70	90 TWh (e)	1200–3000	4–10 ¢/kWh	3–10 ¢/kWh
Geothermal energy							
Electricity	≈4	8 GWe	45–90	46 TWh (e)	800–3000	2–10 ¢/kWh	1 or 2–8 ¢/kWh
Heat	≈6	11 GWth	20–70	40 TWh (th)	200–2000	0.5–5 ¢/kWh	0.5–5 ¢/kWh
Marine energy							
Tidal	0	300 MWe	20–30	0.6 TWh (e)	1700–2500	8–15 ¢/kWh	8–15 ¢/kWh
Wave	–	Exp. Phase	20–35	Unclear	1500–3000	8–20 ¢/kWh	Unclear
Current	–	Exp. Phase	25–35	Unclear	2000–3000	8–15 ¢/kWh	5–7 ¢/kWh
OTEC	–	Exp. Phase	70–80	Unclear	Unclear	Unclear	Unclear

Note: The cost of grid-supplied electricity in urban areas ranges from 2–3 (¢/kWh (off-peak) to 15–25 ¢/kWh) (peak). Heat embodied in steam (or hot water in district heating), often produced by combined heat and power systems using forest residues, black liquor, or bagasse.

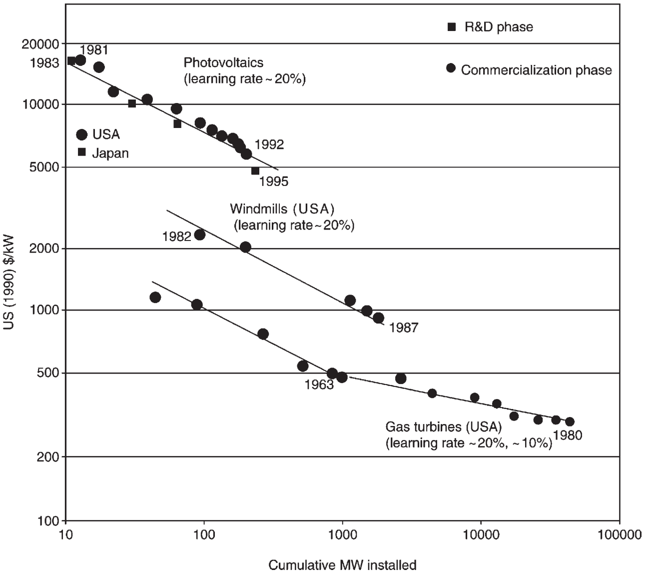

Fig. 2. Learning curves for promising renewables [6].

6.1.2. *Vision and mission*

1. To increase fuel efficiency of process.
2. To increase the productivity and quality of silk produced.

6.1.3. *Objectives and strategies*

To use wood based gasifier to control burning rate and ensure uniform cooking of cocoons between 93 and 97 °C. Successive steps have been taken:

- To make a product acceptable to the users based on systems integration, laboratory trials and field testing leading to commercial production.
- To ensure economic viability of the innovation.
- To use multiple fuels (cheaper and available as waste)via briquetting route in the gasifier possibly without modification.

6.1.4. *Financial parameters*

Based on fuel conservation and improved and enhanced rate of silk production and taking interest rate on loan of 10% (the realistic value for a small unit processing 100 kg cocoon per day an investment of Rs 65,000 (45 Rupees = 1 US$)) and annual maintenance cost at 2.5%, payback period is 126 days, break even ratio is achieved after 16 days and return on investment is 238%.

6.1.5. *Business activity plan*

It is clear from this exercise that part of business development plan has to be systems integration for a process/location in case of renewable energy systems which

include laboratory trials to field model. This is a time consuming iterative process and has taken nearly 2.5 years and has to be externally funded and may later be included in the commercial price of the unit depending upon the success of reorienting the market. This is the weakest link in innovation chain supporting the induction of renewables in rural industries (Fig. 3).

6.1.6. Outreach plan

This has to be developed along with manufacturers of the unit with the price being fixed by conditions of production costs as well as affordability of small scale producers cushioned by investment allowances and production benefits. An industrial model of the unit in use for testing purposes is shown in Fig. 4.

6.1.7. Impacts

1. Wood saving of 1.35 kg fuel/kg of cocoon which is nearly 58% of existing practice and additional silk production of 3.8% along with better quality and therefore marketability at marginal price increase of 1.5%.
2. Direct job creation for wood cutting, briquette making and indirectly manufacturing jobs along with installation and maintenance crews.
3. Ensuring competitiveness and survival of the industry.

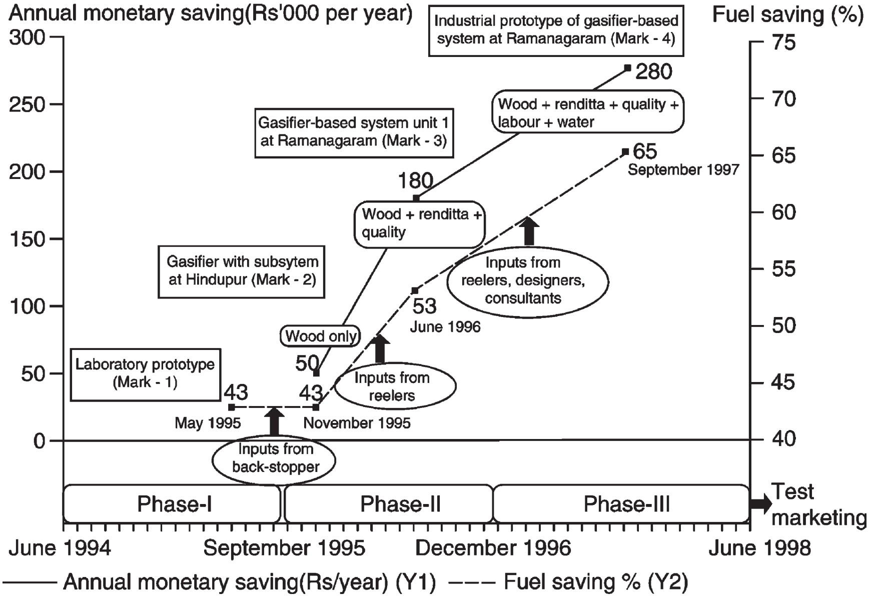

Fig. 3. Assimilation and development process for the Renewable Technology with attendant spinoffs (TERI).

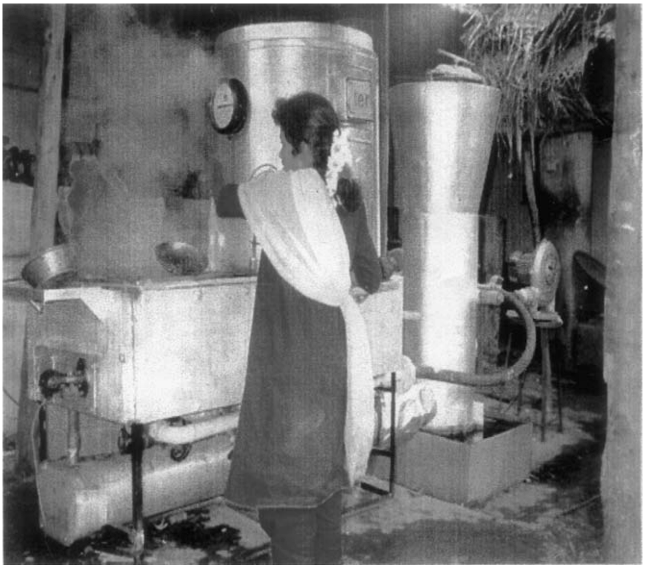

Fig. 4. Industrial prototype model under field testing gasifier based silk reeling oven (TERI).

6.2. Mini solar power grids in sunderbans, West Bengal [8]

6.2.1. Introduction

The Sunderbans delta in West Bengal in Eastern India consists of several islands inhabited by farming and fishing communities. Electrification through under water cables from the main land is economically non-viable and captive diesel sets have high costs, noise pollution and problems of diesel transportation. More than 20 units of 25 kWp stand alone SPV systems have been installed by the State Nodal Agency for Renewable Energy since 1993. The islands are roughly 100 km away from the metro city of Kolkata.

6.2.2. Vision and mission

1. To provide quality power via mini grid to concerned island on a viable operational basis.
2. Community participation is necessary for assuring proper operation and collecting revenue from the plant.
3. It will improve quality of life by providing assured home power to be extended to productive uses on demand.

6.2.3. Objectives and strategies

1. To use SPV power plants (25 kWp) each and in some cases Sun–Diesel Hybrid and Biomass Gasification systems up till 500 kW) for supplying 220 V quality grid power to homes and commercial facilities.

2. To enhance quality of life and increase income potential via cottage industries and running night schools.
3. Nodal Agency acts as technical consultant and intermediary for procuring quality components and dealing with contractors to install and commission 25 kWp decentralized power plants.

6.2.4. Financial projections

Each 25 kWp mini grid	Rs 10 million
Government subsidy	50%
Term loan on low interest via IREDA from World Bank	40%
Down payment by users via local Nodal Agency	10%

6.2.5. Business activity plan

The grid is operated and maintained by village cooperative society, which also collects service fees. Tariffs are based on connected loads and service is only during evening for 3–4 h controlled from the control station. Rates are Rs 70 per month for 70 W load, Rs 120 per month for 120 W load, and Rs 540 per month for 700 W load (last ones being used for video and marriage halls). This comes to a tariff of more than Rs 10/kWh but it is paid happily.

6.2.6. Outreach plan

Initially the power is used for homes and community facilities only. There is demand for running a solar pump for irrigation and a flour-grinding machine, which generates employment. There is also demand from cottage industries.

6.2.7. Projected impact

It has revolutionized the entire life pattern of these isolated villages without any ecological costs and at affordable prices as there are no lapses in paying the bills, being locally administered.

6.3. Polyhouses in Himalayas for nutritional security [9]

6.3.1. Introduction

At Himalayan heights above 3000 m above MSL, which are snow bound for most of the winter, it is very difficult to get greens as the growing season is very short. This results in the incidence of vitamin deficient diseases like beriberi etc. Polyhouses, which can grow quality vegetables and solar dryers, which can dry them for the winter are very much needed and can provide a solution to the above problem. Kassar Trust, an NGO operating in the Kumaon Hills, initiated this action at local level in remote villages, by building polyhouses for growing seedlings from quality

seeds from a local laboratory-in the Kumaon (Vivekananda Laboratory at Almora) initially as a starting phase. These seedlings were later sold to neighboring farmers at a good price with better yields in quantity and quality. The irrigation was done using harvested rain water stored in tanks and pumped out by using hand pumps.

6.3.2. Vision and mission

1. To provide nutritional security to average hill folks.
2. To create livelihood supplement by growing seedlings.

6.3.3. Objectives and strategies

1. Quality seeds were provided free of cost by Kassar Trust.
2. Polyhouse cover material i.e. 100 μg Green house grade LDPE/PVC sheets were to be provided free along with technical supervision.
3. Land, labor and wooden structure were to be provided by the farmer, who grew the seedlings and marketed them.

6.3.4. Financial projections

The seedlings are grown for 6 weeks after the seeds are planted so as to be ready in the beginning of summer (May–June) for transplanting to fields. They are sold for Re 1 but the price depends upon the demand and the type of vegetable as it is related to the price at which product sells. For farmers it is extra income as no expense is there apart from occasional watering. Also, if the polyhouse is adjoining to the cattle shed in the ground floor of the house, it keeps their shed slightly warmer.

6.3.5. Business activity plan

There is no plan except that many more farmers are encouraged to do this to increase the availability of greens during summer and some dried vegetables in the winter. This helps in counteracting vitamin deficient diseases.

6.3.6. Outreach

In the Dafart and Pindari areas of Kumaon region (beyond Almora) of Himalayas.

6.3.7. Impact

As of 2001, Kassar Trust report states that polyhouses have further penetrated into the society not only for growing seedlings but for growing vegetables. Instead of planned seven for the year, they ended backing up 59 units during the year. The seeds have now to be paid for. Improved varieties of vegetable seedlings of tomato, pumpkin, brinjal, capsicum, cabbage, cauliflower, raddish, onion, french beans have been provided in nearly 12 villages and produce vegetables (worth Rs 0.5 million) consumed locally in an year. Growing vegetables is a new venture being cultivated in the Greater Himalayas and active support of Krishi karmis (local agricultural field workers) is crucial to the success of this venture.

6.4. Biogas based public toilets in Maharashtra [10]

6.4.1. Introduction

Provision of sanitary toilet facilities in urban slums and dispersed rural communities is a crying need. Both are difficult not only because of finance but also because lighting and water needed for maintaining the cleanliness of urban toilet blocks are not available (truly, they are in a mess). Rural systems have to find non-reticulated water based solutions. For inner city areas, pilgrim centers and municipal toilets, Shivsadan (an NGO based in Sangli) has used self-paying facilities at a fraction of the cost as compared to much celebrated and costly Sulabh model. Fig. 5 shows one of the earliest blocks using biogas plants, water hyacinth and compost pits [10].

6.4.2. Vision and mission

1. To provide affordable and working community toilet blocks to inner urban areas, floating population in pilgrim towns and other municipalities.
2. Blocks should be self-sufficient in water, energy and maintained by an attendant who draws his/her income from sale of manure and token payment from users.

6.4.3. Objectives and strategies

1. A block of 20 toilets (10 for men and 10 for women) are provided at each site by partially prefabricated components assembled on site. Pour flush wc's are used.
2. The night soil is used to produce biogas, which generates electricity to provide lights and even a pumpset to provide water to an over head tank so that uninterrupted water supply/lights are available in morning and evening hours. Free living quarter on site is made available to the attendant. Spent slurry is further polished by water hyacinth tanks and water hyacinth is composted with part of slurry.

Fig. 5. Biogas based public toilet block at Pandharpur, Maharastra (Shivsadan).

3. If water and electricity are available from city grid, biogas can be used for providing cooking connection to houses.

6.4.4. Financial estimates

1. At 1987 costs—Rs 12,000 per toilet for a block of 20. Foundation costs in high water table areas (cost includes all ancillaries and living quarters for attendant).
2. Government grant: local body investment—50%. Alternatively 'Build, Own and Operate Model' on 30 years basis by the promoters using Pay and Use formula.

6.4.5. Business plan

Nearly 600 users need a total of 20 toilets. These provide 30m3 biogas/day and 15 ton compost/year, which sell in the market at Re 1 per kg (dry). Attendant can earn Rs 1000 per month plus free living quarters. People pay half a rupee per use.

6.4.6. Outreach

All urban slums, pilgrim centers, rural habitations are potential candidates.

6.4.7. Impact

Clean surroundings, reduced incidence of water borne diseases and wealth from waste including employment potential for one family apart from outlets for sale of manure.

6.5. Improved cook stoves entrepreneurship [11]

6.5.1. Introduction

Most people in developing countries use firewood or agro wastes and cow dung for cooking. Nearly 30 million improved cook stoves have been introduced since 1980s mainly via government sponsored target-driven programs. The construction and replacement rate has been rather low. But some entrepreneurs have adopted a demand-driven corporate services model with great success and achieved 99% success by continuing use of stoves even after 10 years of installation.

6.5.2. Vision and mission

1. To install, service and guarantee fuel wood stoves (ASTRAOLE[1]) suitable for the user against cash payment and only on demand.
2. To instruct housewives in using best practices for getting optimal fuel saving, improved smoke-free indoor air quality and reduced time of cooking. This is ensured by at least two subsequent visits.

[1] ASTRAOLE stove is based on comprehensive researches carried out at ASTRA centre of Indian Institute of Science, Bangalore.

6.5.3. Objectives and strategies

1. To ensure the success of stoves following the same practices as used by dealers of white consumer goods for urban users.
2. Best quality stoves are constructed for only motivated users without subsidy and on demand only.

6.5.4. Outreach and impact

The percentage of households that discontinued the use of improved ASTRA stoves and went back to traditional stoves was less than 3% in 2001. However, due to availability of LPG/biogas in the area during 7 years after first survey, nearly 35% shifted away from firewood stoves. This highlights the impact of conflicting policies in the same area. Post-construction service and user training have been key to successes.

6.5.5. Financial aspects

In 1990 the cost of ASTRAOLE was Rs 120 and in 2001 it costed Rs 600 but more than 100 stoves have been built every year in the local area. Currently the entrepreneur earns Rs 200 per stove and he has diversified into making efficient bath water heaters and thus kept fully engaged. Now it is the second generation operation over 10 years.

6.5.6. Business activity plan

Since the fuel wood saved is nearly one-third of what is used otherwise and repairs and necessary replacement are assured, continued demand is ensured. However, when saturation is reached, the radius of operation may have to be increased. Materials are normally obtained by the user as per list and entrepreneur provides only construction skills apart from some hardware (not easily available in rural areas).

6.6. Fixed dome biogas plants in Orissa [12]

6.6.1. Introduction

Introduction of biogas digesters for using organic cellulosic wastes from draft animals and food/dairy industries in rural areas have been an integral plank of rural development of-independent India since last 50 years. A new model of biogas plant namely Deenabandhu plant (friend of the poor) was developed in the region and extensively disseminated via a participatory mode in nearly 500 villages of Orissa by an NGO named Gramvikas, as reported by Madiath [12].

6.6.2. Vision and mission

Development of marginalized communities via generating sustainable livelihoods through:

- ecologically sound enhancement of resources;
- ensuring access to basic education, primary health care, safe drinking water and hygienic environment;

- enhancing self-esteem of the participating users via self-governance.

6.6.3. Objectives and strategies

- Two program are in operation: (1) Integrated tribal development program, (2) rural health and environment program. Originally started to reduce deforestation, the biogas program was meant to utilize animal wastes from the sizeable cattle population normally available with tribal villages. It later became a part of National Project of Biogas Development for providing clean fuel for cooking along with manure.
- Scaled up operation in all districts of Orissa as a challenge to NGO's capacity to spearhead technology intervention in a cost effective manner.

6.6.4. Financial aspects

It is based on graded subsidies and bank loan initially. From 1994, masons and supervisors were encouraged to form self-reliance guilds to do turn key jobs, with technical backup by the original NGO (Gramvikas). The program is now operating in 100 villages of Orissa.

6.6.5. Business activity plan

1. A new model (to remove the bottleneck of Chinese Biogas plants) was developed for 2–6m3 biogas/day capacity.
2. Launching a training program for masons and youth recruited from amongst local village population—5000 masons were trained in this technology.
3. Supervisors had to supervise, do post-construction servicing and preconstruction liason with bank and dissemination to farmers and motivating them to be complete owners of the plant and not just users. They also maintained meticulous record and a log book for each plant.
4. After first 3 years around 1984, the program became demand-driven rather than target pushed program. During 10 years from 1984–1994 more than 50,000 plants were constructed.

6.6.6. Outreach plan

When the program was at its peak 1992–1993 (10,000 plants per year) it evolved into Rural health and Environment program which included safe water supply and sanitary toilets apart from biogas and composting for entire region.

6.6.7. Impact

Clean surrounding, better manuring of fields, free cooking fuel for cattle owners with 82% plants in operation in 1997.

7. Concluding remarks

Three ingredients of success are clear from the successful studies outlined above.

7.1. Human factor

- The credibility, competence and patience of motivating team.
- Local leadership and participation of users in decision making including whether they want the technology at all and if so, what technology? This can take up to 2 years at times but the lost time is made up by word of mouth, once it is successful. This is true for processes as well as products.
- Quality installation taking into account all logistical, social and load demand factors.

7.2. Operation and maintenance requirements

- In hot climates operation and maintenance is must e.g. a coat of paint, dusting, visual inspection etc.
- Models can vary from warranty by suppliers to regular predictive maintenance by trained barefoot technicians selected by the users association and paid by them.
- Requisite tool kits, spares and replacements should be included in the initial budget itself.

7.3. Capacity building

- Appraising users about value and advantage of renewables and the critical points needing attention e.g. school children can be best trouble locators (if not trouble shooters) and vigilance agents.
- Training of rural technicians for local installation, maintenance and all other knowhow. In case of bare foot college, they even manufacture locally solar lanterns in village solar electronic workshops. A suggested training scheme is given in Appendix A.
- Models of capacity building can vary from SWRC's bare foot 'Karmi' to corporate type CREI model of Winrock International [13].
- Regular visits to instill confidence (apart from actual maintenance) at least in rural areas and far flung locations.

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Appendix A. Training course for rural energy entrepreneurs youth livelihood program through renewable technologies

Structure

In modules of 15 days each; 6 days per week + one day test for evaluation. Two hours theory every day; 4 h hands on practical every day for a week + one project for a week. Last day presentation/write up.

Certificate for each module

Certificate

Certificate of eligibility to become a Bare foot Rural Energy Technician: 12 modules to be done together during 6 months training period or in slots of three each during 1 year (maximum).

Diploma

Six more modules are taken subsequently in another 3 months training or individually (where working) in lots of 2 weeks each within 1 year. Qualifying for getting the diploma of a Barefoot Master Technician for Rural Energy. Eighteen modules will qualify the candidate as an approved entrepreneur to do fabrication, to supervise maintenance contracts; to train technicians for projects and to start energy service companies (ESCOs), do energy surveys and prepare prefeasibility studies.

Modules

Modules shall be more general than just being linked to renewables only so as to provide useful livelihoods for entire gamut of Rural Technology (primarily energy based/centered).

Basic technical skills
- Plumbing
- Wiring and connection sizes of conductors
- Soldering/welding/sheet metal bending/materials familiarity
- Motors principles + repair and pumps
- Energy surveys and analysis of PRA's
- Record keeping/basic accounts/project writing

Renewable energy
- Solar collectors—principles and fabrication
- Solar cookers and efficient cook stoves
- Solar water heaters
- Solar dryers/distillers
- Solar PV home lighting
- Solar PV street lights

Six out of optional courses (theory + hands on)
- Biogas trouble shooting/repair/burners checking
- Wind pumps: aligning/checking/routine maintenance
- Wind electric charger uptill 4 kW—connections
- Gasifier operation and maintenance
- Solar PV pumps
- Solar concentrators for cooking

- Construction of biogas plants
- Solar building systems
- Evaporative coolers
- Airconditioners repairs etc.
- Handpump Repairing
- Changing of foot valves

Job opportunities/self-employment avenues

1. As supervisors in energy projects.
2. As small manufacturing enterprises
3. As maintenance contractors servicing warrantees
4. As trainers of field staff
5. As energy surveyors
6. As preparators of prefeasibility studies
7. As ESCOs providing single window integrated energy systems including liason with banks, government etc., for micro finance credits
8. Subvendors for sourcing quality components

These opportunities may have to be combined with more general requirements of entire scale of rural technologies such as repairing of pumps, motors, agricultural equipments etc., and not just be limited to renewable energy at least currently.

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